Introduction

All living cells require efficient supply of nutrients, oxygen, hormones etc. The cells must get rid of metabolic wastes like CO_2 and nitrogenous wastes. Small organisms meet their requirements of supply of nutrients and oxygen and removal of waste products, simply by means of diffusion. Tiny animals have small size and large surface area so this process of diffusion is sufficient to meet their required transport of substances.

The larger and active animals like human cannot rely on diffusion alone. Therefore these animals must need an efficient transport system.

This chapter deals with human transport system and its components i.e., Heart, blood, blood vessels and blood pressure and cardiovascular disorders.

Tit bits

The study of diseases of cardiovascular system is called angiology.

12.1 Blood Circulatory System of Man

Human blood circulatory system is composed of following parts i.e., a muscular pumping organ called heart, a system of interconnecting tubes called blood vessels and a circulatory fluid, the blood. The blood always remains in the vessels so the system is known as closed circulatory system.

12.2 Human Heart

The heart of an adult human has a mass of around 300 grams, and is about the size of our fist. It is the most powerful organ in the circulatory system. The heart lies in the thoracic cavity between the lungs, slightly towards left, enclosed within the rib cage, with the sternum in front and vertebral column behind. It is surrounded by a double layered **pericardium.** A pericardial fluid is secreted in between these two layers. It lubricates and reduces the friction between the heart walls and surrounding tissues during the beating of heart.

Do you know?

Dr. Christen Barnard carried out the first heart transplant in 1967. The recipient, Louis Washkansky only lived for 18 days after transplant but now most of heart transplant patients are expected to survive for the rest of their life.

Tit bits

Cardio-logy from Greek Kardia, "Heart" and logia "study" is a branch of medicine dealing with disorders of heart as well as parts of circulatory system.

Structure of Human Heart

The heart is conical in shape and dark red in colour. The heart has four chambers, a **left and right atrium** at the top, and a **left and right ventricle** beneath. The right side is completely separated from the left side by a **septum.** The walls of heart are made almost entirely of a special kind of muscles called cardiac muscles. It is the regular contraction and relaxation of these muscles which produces the pumping movement of the heart called **heart beat.**

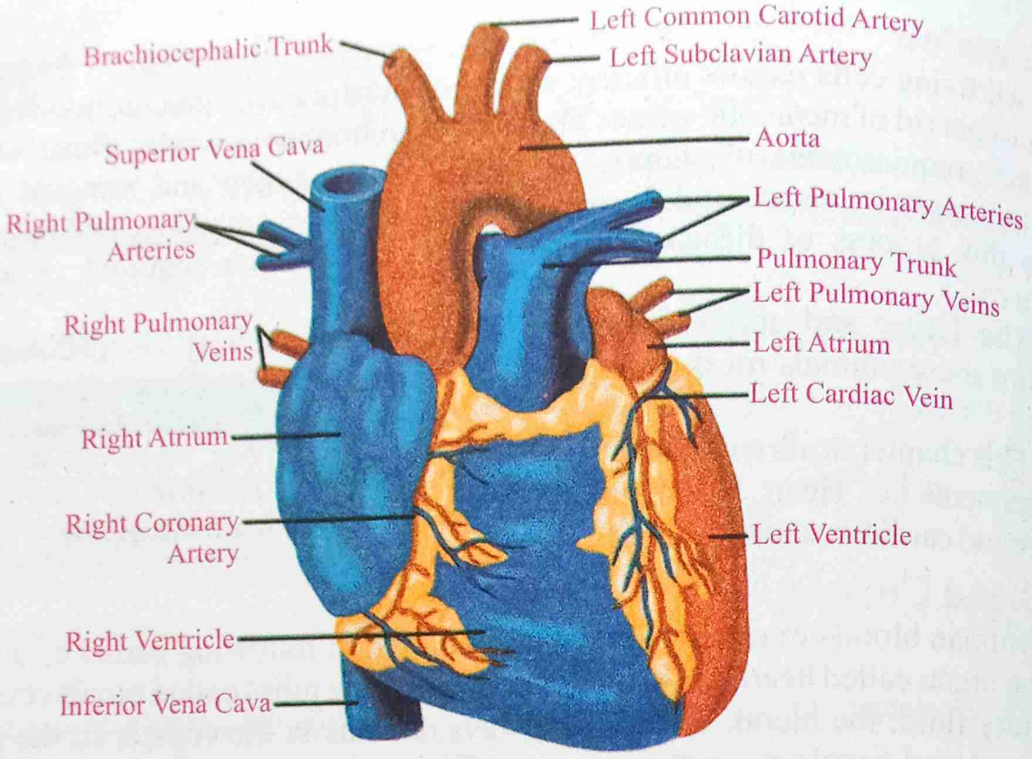

Fig. 12.1 External Structure of Heart

The **atria** on each side of the heart are separated from the **ventricles** by valves. These are atrioventricular valves (AV valves). The one on the left is often known as

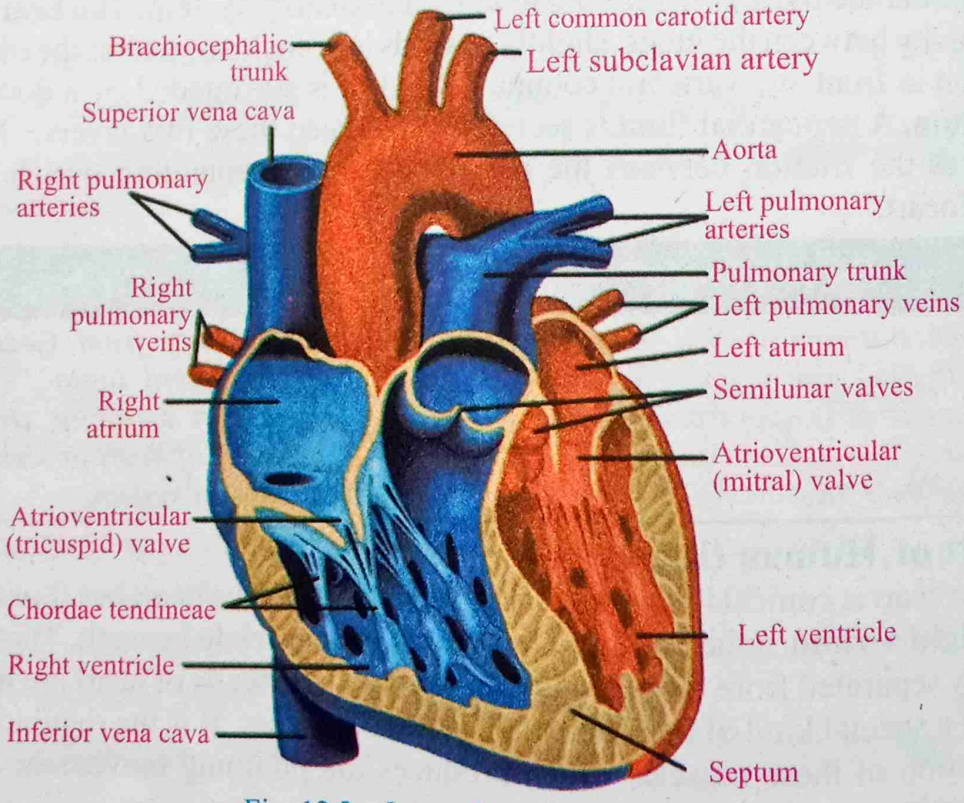

Fig. 12.2 Internal structure of heart

mitral valve, or alternatively the **bicuspid valve** because it has two flaps. The one on the right side is called **tricuspid valve.** The valves control one way flow of blood i.e. from atria to ventricles but prevent back ward flow.

The **semilunar valves** guard the emergence of pulmonary arch and systemic aorta. These valves also prevent backward flow of blood. On the outside of heart blood vessels can be seen. These are called **coronary arteries** which deliver oxygenated blood itself to the heart walls.

The heart wall is formed of three layers:

Epicardium: outer most, **Myocardium**, middle, **endocardium**, innermost. The epicardium is thin and comprising of smooth outer surface of heart. The myocardium is thick and composed of cardiac muscle cells. The endocardium consists of simple squamous epithelium.

Tit bits

Heart block is a disease or inherited condition that causes a fault within the natural pace maker of the heart, due to some kind of obstruction or block in the electrical conduction system of heart.

12.2.1 Heart Beat and its Control (cardiac cycle)

Adult human heart beats around 72 times per minute. One heart beat is called cardiac cycle. A cardiac cycle is a sequence of events which takes place in the heart during one heartbeat. First the atria contract; this is called **atrial systole**. As a result of this contraction blood is forced into the ventricles through atrio-ventricular valve now the ventricles contracts. This stage is called **ventricular systole.** The walls of ventricles are thicker and stronger than atrial walls, so they can produce much greater force. The blood is squeezed up into the aorta from the left ventricle and the pulmonary artery arises from the right ventricle. The

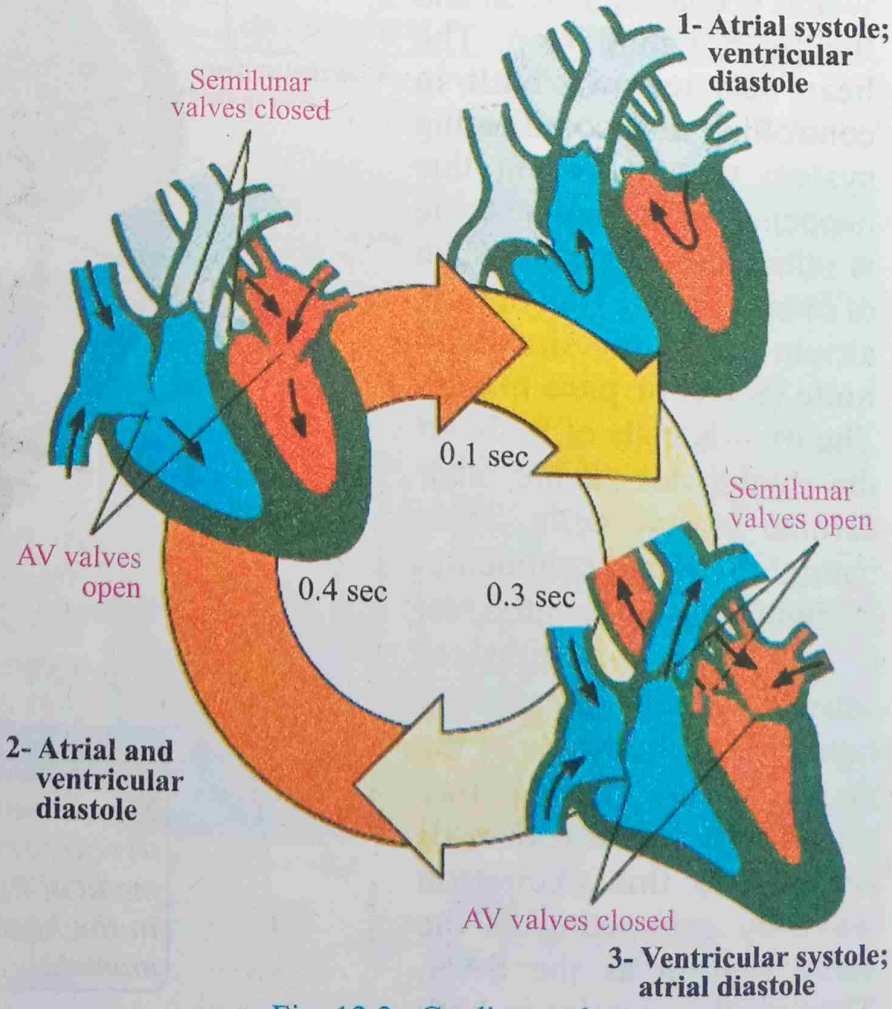

Fig. 12.3 Cardiac cycle

pressure of the blood in the ventricles pushes upward on the atrioventricular valves, pushing them shut. So if the valves are working properly no blood can go backwards into the atria. Next the muscles in the atria and ventricles relax. This is called **diastole.**

12.2.2 Conducting System of the Heart

The cardiac muscles are **myogenic.** This means that these muscles contract and relax naturally. Heart does not need to receive impulses from a nerve to make it contract. If heart is kept in warm oxygenated solution containing nutrient's, the heart muscles will contract and relax rhythmically by themselves. However the individual heart muscle cells can not be allowed to contract at their own natural rhythms because if so the part of heart would contract out of sequence with other parts, the cardiac cycle would become abnormal and the heart would stop. The heart has its own built in controlling and coordinating system which prevent this happening. The cardiac cycle is initiated in a special patch of muscles in the wall of right atrium called the **sinoatrial node (SAN) or pace maker.** The muscle cells of SAN set the rhythm for all the other cardiac muscle cells. Their natural rhythm of contraction is slightly faster than the rest of the heart's electrical activity, which spreads out rapidly over the whole of the atrial walls. The cardiac muscle in the atrial wall respond to this excitation wave by contracting as the same rhythm as the SAN. Thus all the muscles in both

Do you know?

Cardiac output: The volume of blood leaving the left ventricle is known as stroke volume.

Cardiac output is the volume of blood leaving the left ventricle per minute so cardiac output = stroke volume x heart rate.

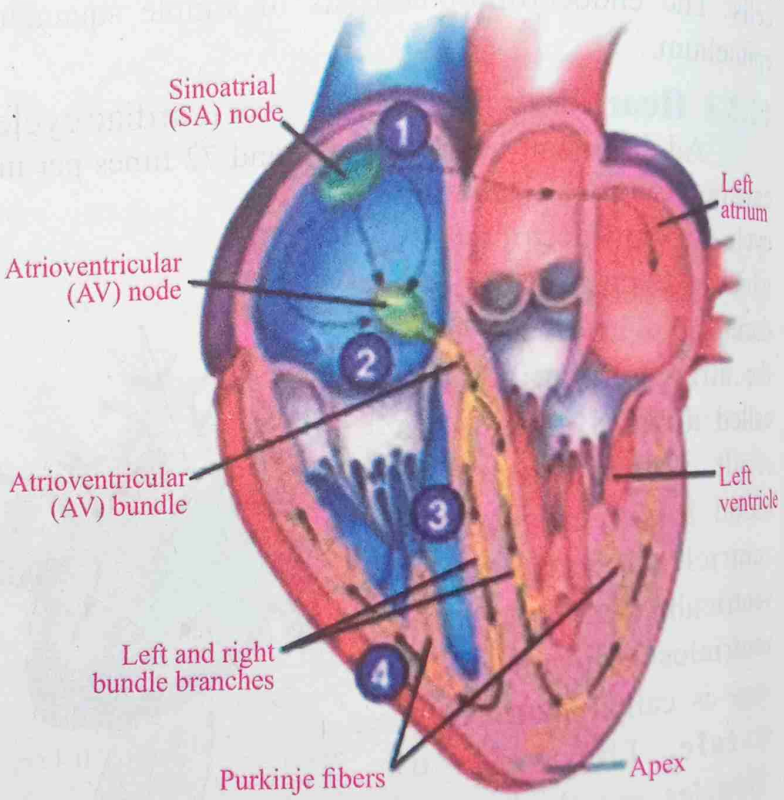

Fig. 12.4 SA node AV node

Tit bits

The sinoatrial node was first discovered by a young medical student Martin Flack in the heart of mole, A small mammal.

atria contract almost simultaneously.

As we know the muscles of ventricles do not contract until after the muscle of atria contract. This delay is caused by a feature of heart that briefly delays the excitation waves in its passage from atria to ventricles.

There is a band of fibers between the atria and ventricles which does not conduct the excitation wave. Thus as the wave spread out from the SAN over the atrial walls, it cannot pass into the ventricle walls. The only route is a patch of conducting fibers situated in the septum, known as atrio-ventricular node (AVN). The AVN picks up the excitation wave as it spreads across the atria. Besides, there is a bundle of nerve fibers called atrioventricular bundle (AV) or "Bundle of His" arising from AV Node, it pass through the septum in between the ventricles and divides into right and left bundle branches. Numerous conducting fibers called "Purkinje Fibres" arise from the branches and spread over the ventricles.

12.2.3 Electrocardiogram

The electrocardiogram (ECG) also known as EKG. It is a non invasive device that measures and records the electric activity of the heart over a period of time using electrodes placed on the skin. These electrodes detect the tiny electrical changes on the skin that arise from the heart muscles that is electrophysiological pattern of depolarization and repolarization during each heartbeat.

Tit bits

An elctrocardiograph is a machine that is used to perform electrocardiography and produces the electrocardiogram.

The first part of the wave called "P" wave is a small increase in the voltage of about 0.1 mV that corresponds to the depolarization of the atrial systole. The next part of ECG is the "QRS" complex which features a small drop in voltage (Q) a large voltage peak (R) and other small drop in voltage (S). The "QRS" complex corresponds to the depolarization of the ventricle during ventricle systole. The atria also repolarize during the "QRS" complex but have almost no effect on the ECG because they are quite smaller than ventriclular waves.

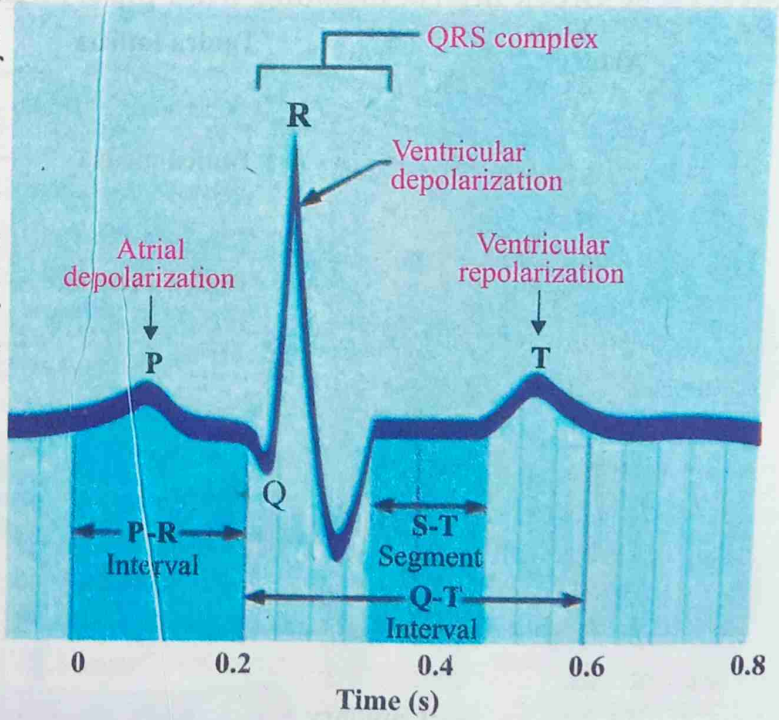

Fig. 12.5 ECG

The final part of ECG wave is the "T" wave, a small peak that allows the QRS complex occurs just prior to ventricular contraction. The "T" wave represents the ventricle repolarization during the relaxation phase of the cardiac cycle.

The overall goal of performing electrocardiography is to obtain information about the function of heart e.g., suspected myocardial infarction, suspected embolism, increase in size of heart, to access the severity of electrolytes abnormalities etc.

Do you know?

Sinus bradycardia is a sinus rhythm with a rate that is lower than normal. In humans bradycardia is generally defined to be a rate of under 60 beat per minute, while sinus tachycardia is a sinus rhythm with a elevated rate of impulses usually greater than 100 per minute.

12.3 Blood Vessels

There are three major types of blood vessels i.e. arteries, veins and capillaries. **Arteries** always carry blood away from heart. All arteries carry oxygenated except pulmonary arteries. The largest artery **(aorta)** divides into smaller one and these continue to divide to form much smaller vessels called **arterioles**. These in turn divide further into smaller vessels called **capillaries.** These capillaries then join up with each other to form **venule** and these finally merge to form **veins.** These bring the blood back to heart. All veins bring deoxygenated blood except pulmonary veins. Veins unite to form venae cavae.

Tit bits

The aorta is the largest artery while vena cava is the largest vein in the body.

Arteries: Greek arteria meaning wind pipe. Arteries are

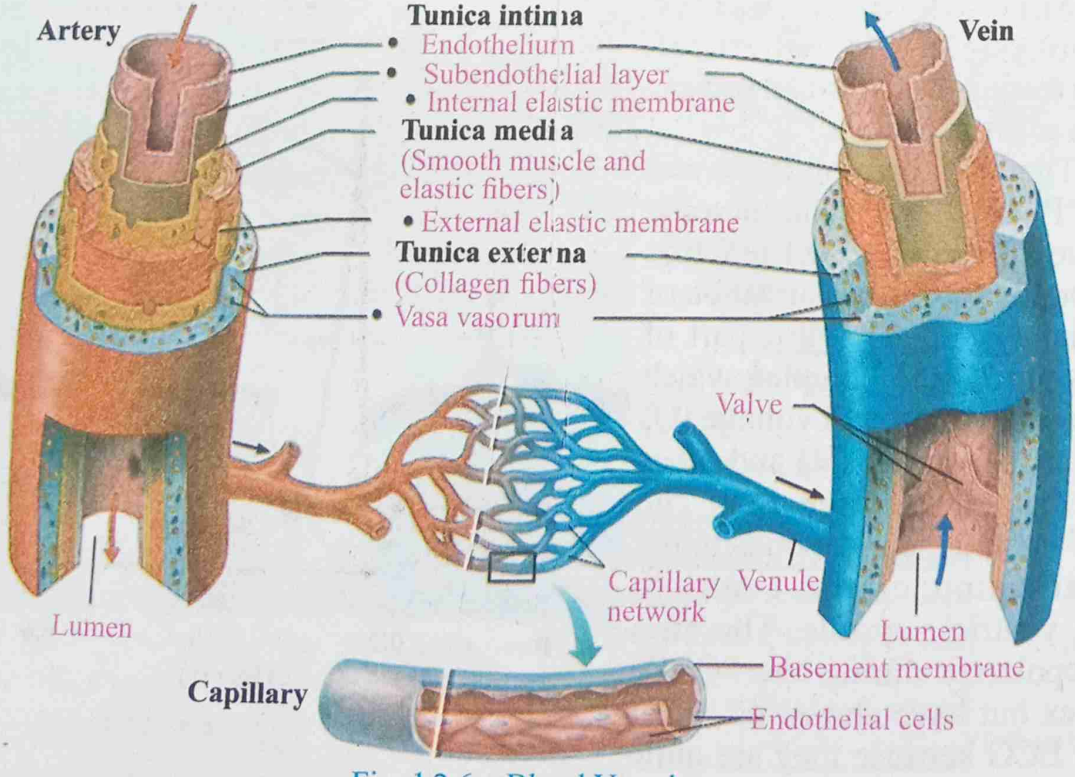

Fig. 12.6 Blood Vessels

thick walled vessels consisting of three layers. The outer layer of an artery is known as **tunica externa** and is composed of connective tissues made up of collagen fibers. Inside this layer is **tunica media** which is made up of smooth muscle cells and elastic tissue. The innermost layer which is in direct contact with the flow of blood, is the **tunica intima.** This layer is made up of epithelial cells.

Capillaries: These are the smallest and thinnest of blood vessels in the body. The intimate relationship between the circulatory system and the tissues is achieved at the level of capillaries. The function of capillaries is to carry blood as close as possible to all cells allowing rapid transfer of substances between cells of the body. Human capillary is approximately 7 to 9 μm in diameter almost same size as a red blood cells, which can, therefore, only pass along the capillary in single file. Moreover the walls of capillaries are extremely thin, made up of a single layer of endothelial cells. This thinness of capillary walls helps to speed up the exchange rate of materials with the tissues.

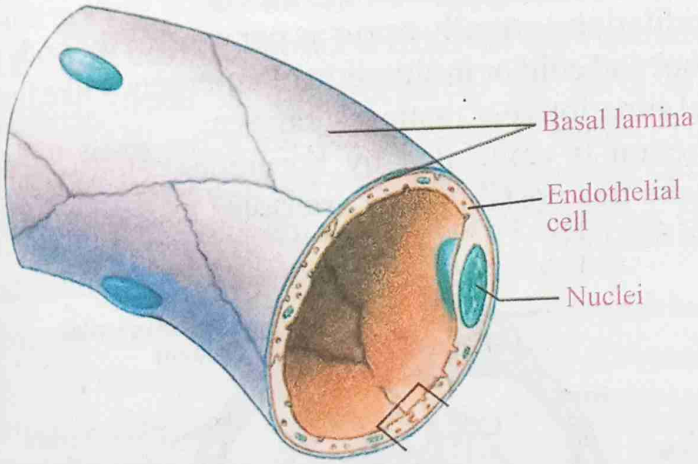

Fig. 12.7 Capillary

Veins: Veins are the blood vessels that bring blood back towards heart. Most veins carry deoxygenated blood except the pulmonary and umbilical veins. Veins are less thick and less elastic than arteries. Moreover veins have relatively larger lumens than arteries.

A vein consist of three main layers. The outer thicker layer made up of connective tissue called the tunica externa or tunica adventitia. The middle layer is called tunica media and is composed of smooth muscle. This layer is quite thinner than arteries. The inner most layer is called tunica intima.

Tit bits

Cornea and cartilage lack capillaries. Therefore these structures are slow to heal if injured.

Tit bits

Veins are called capacitance vessels because most of blood volume (60%) is contained with in veins.

Tit bits

The veins appear blue because the subcutaneous fat absorb low frequency of light and reflect blue light.

Cardiac veins: *The vessels that remove deoxygenated blood from the heart muscles.*

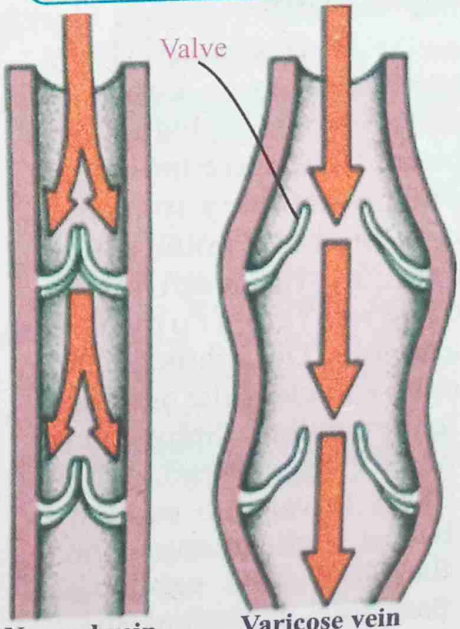

Fig. 12.8

The largest vein in human body is vena cava which enters the right atrium of heart from above and below.

The venules are small veins that collect blood from capillaries which then drai into veins.

Valves in veins: Veins mostly contain valves which prevent back-ward flow of blood These valves are present in larger veins having diameter greater than 2mm. Howeve these valves are needed only in lower part of the body such as veins of hind limbs an abdomen, without these valves the flow of blood towards heart is very slow and difficult.

12.3.1 Role of arterioles in vasodilation and vasoconstriction

Vasodilation means widening of blood vessels as a result, blood flow increases due to decrease in vascular resistance (Due to increase of diameter of vessel.)

Vasoconstriction is the narrowing of blood vessels to decrease, blood flow due to increase in vascular resistance (Due to decrease in diameter of vessel).

The vasoconstriction and vasodilation normally occur as per need of the body e.g., to regulate body temperature during hot and cold or in situation of emergency like flow of blood from injury or during emotional situations e.g., sadness, rage etc.

Vasodilation and vasoconstriction is controlled by hormones. However thick smooth muscle layer in arterioles make this possible. The arterioles usually have large number of smooth muscles to perform this task.

12.3.2 Role of Pre-capillary sphincter in regulating the flow of blood through capillaries

A pre-capillary sphincter is a band of smooth muscle that adjust blood flow into capillaries. The pre capillary sphincter is located at a point where each of the capillaries originates from the arteriole. The sphincter can open and close the entrance to the capillary. Sphincter is unable to contract when blood flows into capillary bed at high pressure, then the fluid from capillaries pass into interstitial space and edema may result.

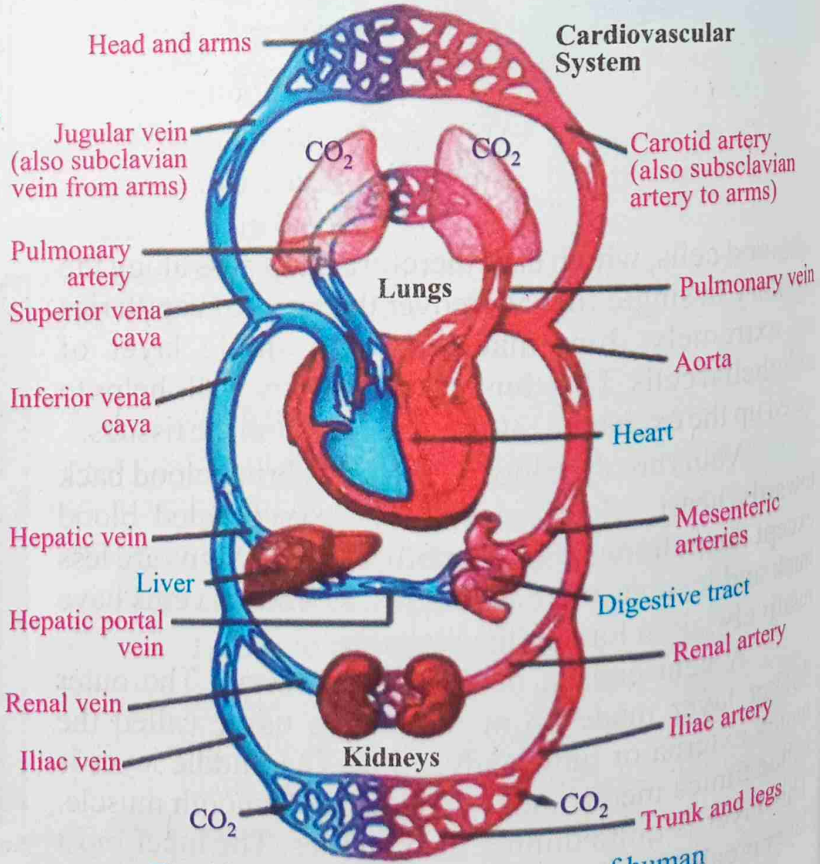

Fig. 12.9 Cardio-vascular system of human

12.3.3 Vascular Pathway

The blood vascular system may be divided into two parts i.e. pulmonary circulation and systemic circulation.

Pulmonary circulation:

The pulmonary circulation is also called pulmonary circuit. This portion of blood circulatory system carries deoxygenated blood away from the right ventricle of heart to lungs and returns oxygenated blood to left atrium and then into the left ventricle of the heart. The deoxygenated blood leaves the heart through pulmonary arteries while oxygenated blood enters into left atrium through pulmonary veins.

Systemic circulation:

The systemic circulation is the portion of the blood vascular system which transports, oxygenated blood away from the heart through the aorta from the left ventricle. This oxygenated blood is transported to all parts of body including heart muscles but excluding lungs. The left atrium is receiving and left ventricle is pumping chambers for systemic circulation. The right atrium is the receiving chamber of systemic circulation. It receives deoxygenated blood through inferior and superior venae cavae.

Tit bits

Portal hypertension is a condition in which the blood pressure of the portals system is too high which may cause cirrhosis of liver.

Coronary circulation:

The circulation of blood into the blood vessels of heart muscles i.e., myocardium is known as coronary circulation. Two coronary arteries originate from the left side of the heart at the beginning of aorta. There are two main coronary arteries i.e. left coronary which supplies oxygenated blood to left side of heart and right coronary artery which supplies oxygenated blood to the right side of heart. The deoxygenated blood is taken back to right atrium by cardiac veins.

Hepatic portal system:

The portal system is formed when a capillary bed pools into another capillary bed through veins without going through the heart. The some examples of the portal system are hepatic portal system and renal portal system in poikilotherms. The hepatic portal system is a system of veins related to digestive tract and its tributaries. It is also called the portal venous system. Hepatic portal system is responsible for directing blood from digestive tract to liver. So the substance absorbed in the small intestine travel first to the liver where these are metabolised and processed before sending towards the heart.

Tit bits

When the heart`s natural pacemaker is defective then the rhythm of heart disturb. This may cause many problems and prove fatal. Therefore artificial pace maker is needed for regulating the heart`s rhythm.

Tit bits

The hepatic portal system is present in all vertebrates while renal portal system present only in poikilotherms vertebrates.

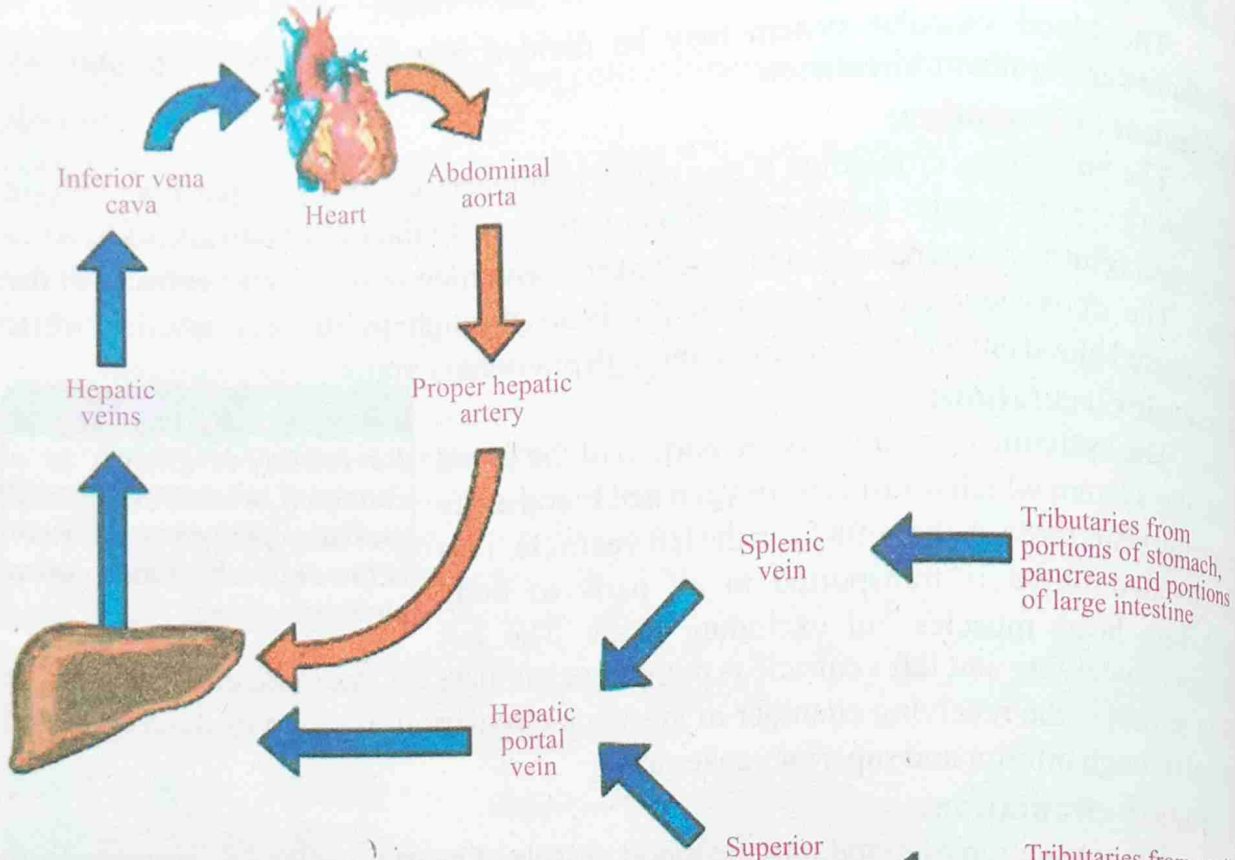

Fig. 12.10 Hepatic Portal Circulation

Renal circulation:

Renal circulation implies the circulation of blood to the kidney via renal artery for filtration and the collection of filtered blood towards heart. Renal arteries normally arise from the side of the abdominal aorta and supply blood to kidneys. The renal arteries carry large portion of total blood flow to the kidneys. Up to one third of total cardiac output can pass through the renal arteries to be filtered by kidneys.

Rate of blood flow in blood vessels:

Blood is circulated around the body through blood vessels by the pumping action of the heart. The rate of blood flow varies greatly in different blood vessels and tissues. It is high in larger vessels and decreases with the division of blood vessels and lowest rate is observed in capillaries.

Tit bits

Liver has the most abundant blood supply with approximate blood flow of 1350ml/min. kidneys and brains are second and third most supplied organs with 1100 and 700 ml/min respectively.

12.4 Blood pressure

The term blood pressure refers to the force exerted by the blood on the walls of blood vessels as it passes through them. Blood pressure is most commonly measured via a **sphygmomanometer** in which the height of a column of mercury reflects the circulatory pressure. There are two different pressures which are commonly measured, systolic pressure and diastolic pressure. The **systolic pressure** is the maximum pressure produced in the left ventricle during systole. The **diastolic pressure** is the pressure in the aorta at the end of diastole.

Tit bits

Baro reflex is one of the blood homeostatic mechanisms that helps to maintain blood pressure.

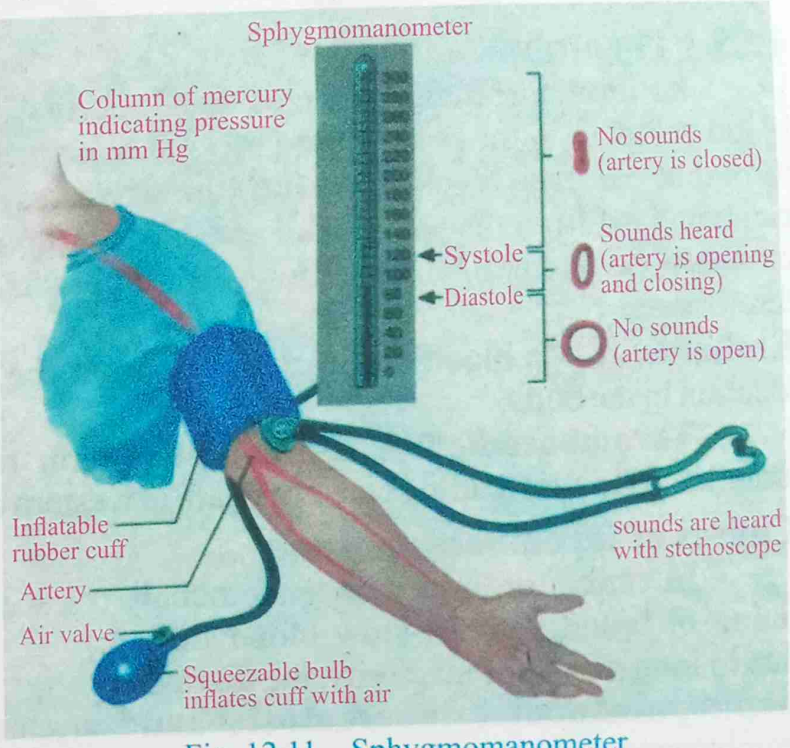

Fig. 12.11 Sphygmomanometer

Baroreceptors:

The blood vessels of vertebrates posses baroreceptors which sense the blood pressure. Then relay the information to the brain so that proper blood pressure can be maintained. These receptors are also called as **pressure receptors**.

On the bases of blood vessel baroreceptors can be divided into two types. **High pressure arterial baroreceptor** and **low pressure baroreceptors** also known as cardiopulmonary or volume receptors.

High Pressure Arterial Baroreceptors:

These receptors are located in the walls of aorta and carotid arteries. These receptors sense the blood pressure and convey the information to the nervous system as per need of the body.

Low Pressure Baroreceptors: (volume receptors)

These receptors are located in atria of the heart, carotid arteries and pulmonary vessels. When low pressure is detected the signal is transmitted by these receptors to the hypothalamus in the brain. The hypothamus increases the production of vasopressin which cause water retention in blood. This increases the blood volume as a result blood pressure also increases.

Comparison of the rate of blood flow through arteries arterioles, capillaries, venules and veins:

The rate of blood flow varies in different blood vessels. In arteries blood flow is

highest as it is pushed out of heart. In adult human, the rate of blood flow in blood vessels at rest (cardiac out put) is about 5 liters/min.

In capillaries blood pressure is lowest while in veins blood pressure is still low as compared to arteries.

12.5 Cardiovascular Disorders

The disease of heart and blood vessels are known as cardiovascular disorders (CVD). Some examples of CVD are.

> **Do you know?**
>
> *Thrombus is formed, from the platelets, fibrinogen; entrapped RBC and WBC mostly.*

12.5.1 Thrombus

A thrombus is a blood clot that is formed in the blood vessel or in the heart during life and remain there. A thrombus can even block blood flow through a vessel or it can break off from the vessel wall and carried through the circulatory system. The formation of thrombus is called thrombosis.

> **Tit bits**
>
> *Up to 90% of cardio vascular diseases may be prevented if established risk factors are avoided.*

Embolus: It is a blood clot that travels from the site where it is formed, to another location in the body.

Thromboembolism is a collective term for the formation of thrombus and embolus. Which is leading cause of death in western civilization.

Causes of thromboembolism:

Infection or injury in endothelial lining of blood vessels, slow blood flow due to long period of inactivity, the disease like pneumonia, tuberculosis and emphysema.

Effect of thrombosis: Hypertension due to blockage of blood vessels either partly or completely. It blocks supply of oxygen which result in damage, destruction or even death of tissue (necrosis) in that area.

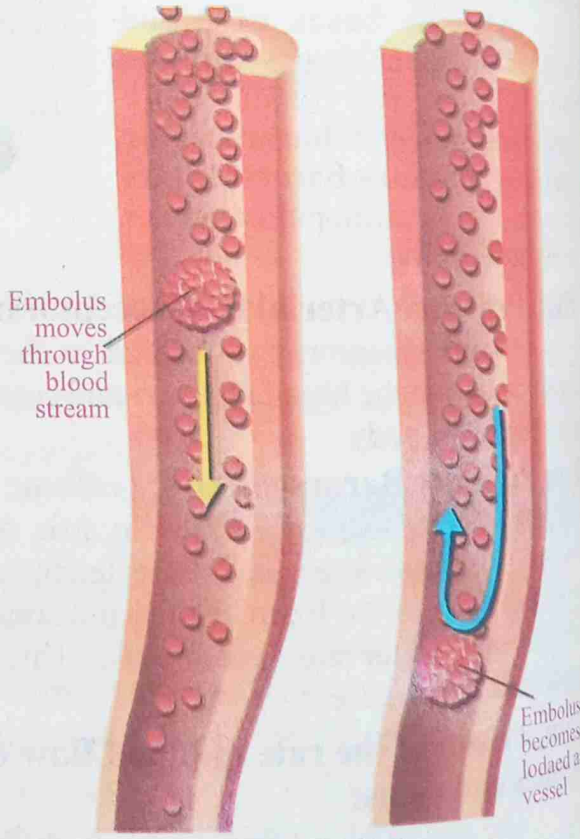

Fig. 12.12 Embolism

12.5.2 Atherosclerosis: (Gk. Athere; Porridge; skeleroe: Hardening)

It is storage of fat deposits on the inside wall of artery. Atherosclerosis is the co-existing antheroma and arteriosclerosis.

The deposition of hard yellow fatty masses called **plaques**, containing large quantities of cholesterol in the inner most

layer (intima) of the arteries is called **atheroma.**

Arteriosclerosis: It is degenerative arterial change associated with advancing growing age primarily a thickening of middle layer of arteries. It causes the arterial lining much rougher than normal. This roughening tends to promote thrombus formation and lead to embolism. It also causes narrowing of blood vessels due to deposition of plaque which obstructs the flow of blood. Ca ions also deposit in the plaque, which loses (weakens) their elasticity and easily gets ruptured.

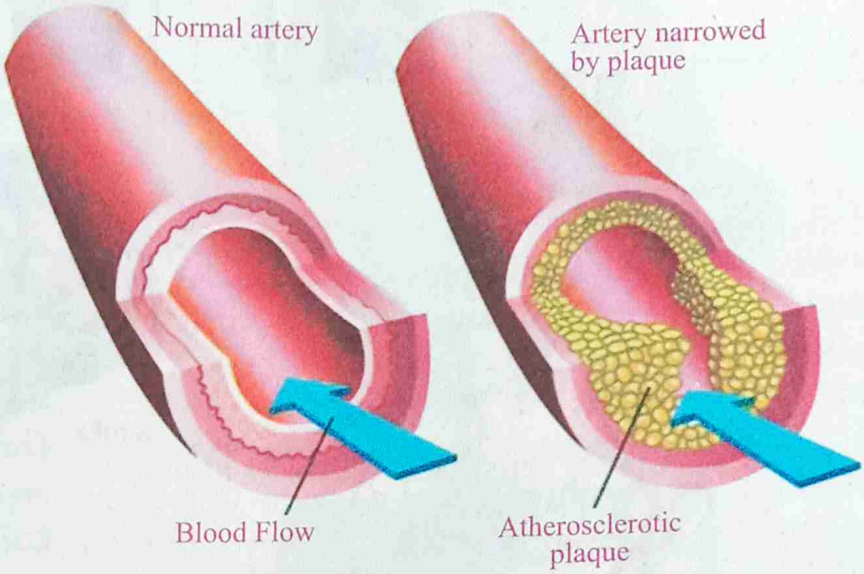

Fig. 12.13 Atherosclerosis

Causes of atherosclerosis:
Hypertension, smoking, hyper lipidemia, diabetes mellitus, lack of exercise and obesity.

Prevention: Do exercise regularly, avoid smoking, use of low cholesterol diet.

Angina Pectoris: If a coronary artery become partially blocked, the individual may suffer from angina pectoris (i.e., chest pain along with pain in the left arm). Angina is an alarming signal that heart is not receiving sufficient supply of oxygen and in future heart attack may occur. **Nitroglycerine** mostly helps to relieve the pain in angina pectoris, because this drug dilates the blocked blood vessels.

12.5.3 Heart Attack

Heart attack is the sudden death of a part of the heart muscle without warning due to sudden reduction of blood supply.

Heart attack mostly occurs when atheorsclerosis reach a critical level and damage large portion of heart or some time a blood clot may causes blockage of blood supply in coronary vessels.

The above factors cause death of a part of heart and the whole process is called myocardial infarction (Myo; muscle, cardium; heart, infarction; death due to lack of

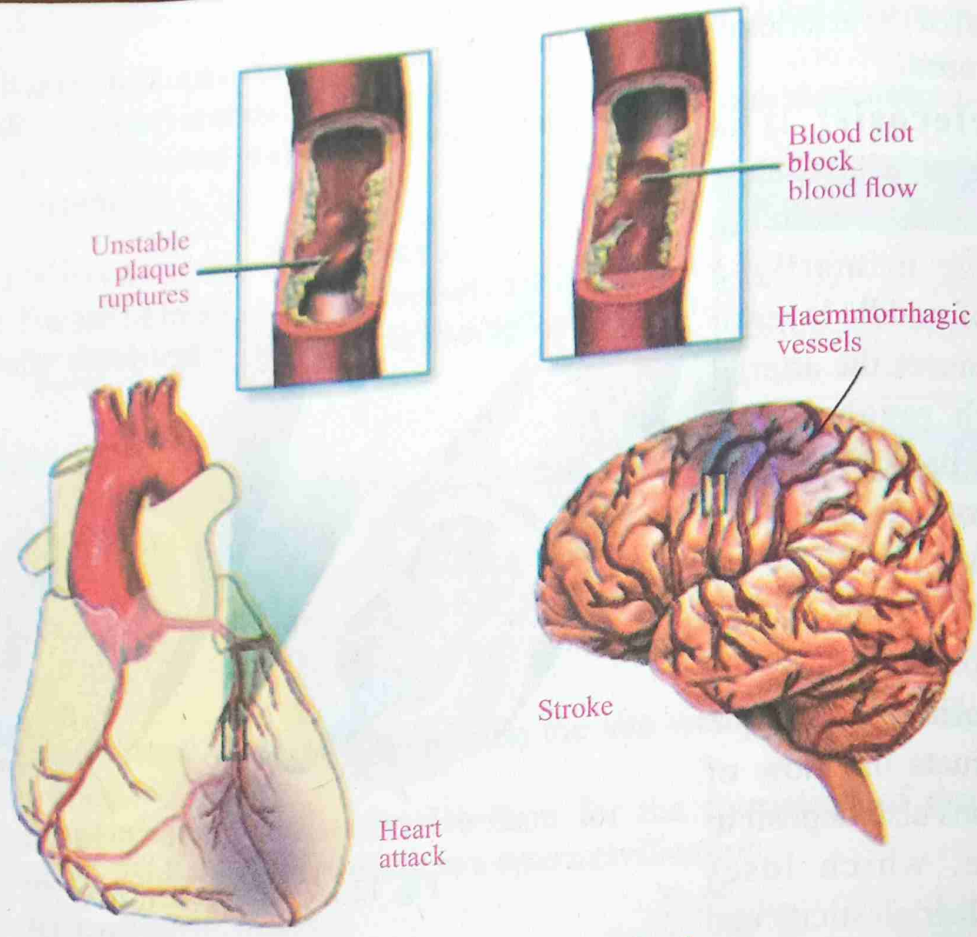

Fig. 12.14 Heart Attack and Stroke

oxygen). Myocardial infarction occurs mostly in individual over 45 year of age. Each year about more than one million people die due to heart attack. Males are more likely to suffer heart attack than females and also smokers than non-smokers.

Heart Failure: It is a clinical syndrome resulting from deficient cardiac volume, relative to body need, with inability of the cardiac output to keep pace with the venous return i.e, heart is unable to pump all the blood coming to it.

Congestive heart problem: It is abnormal function of cardiac valves. **Valvular stenosis** (Narrowing of heart valves due to scarring of its cusps) reduces the diameter of the valve orifice. Severe destruction of valve apparatus may cause valve ring dilation, the **chordiae tendinae** become thicken and shorten, this results in regurgitation of blood through the valve when it is incompletely closed.

12.5.4 Patent Ductus Arteriosus: (PDA)

It is disease of child hood(infant). In fetus, ductus arteriosus is a blood vessel which links the pulmonary artery with aorta. Just after birth when the baby takes its first breath, the lungs become functional and the placenta is cut off, the ductus arteriosus become closed.

Sometimes it fails to do so. This causes **blue babies** due to mixing of oxygenated

and deoxygenated blood.

The symptoms include high heart beat, shortness of breath, respiratory problems etc. The causes are usually unknown but may be due to preterm birth, chromosomal abnormalities and this disease is treated by surgical procedure. Untreated PDA may lead to heart failure and death.

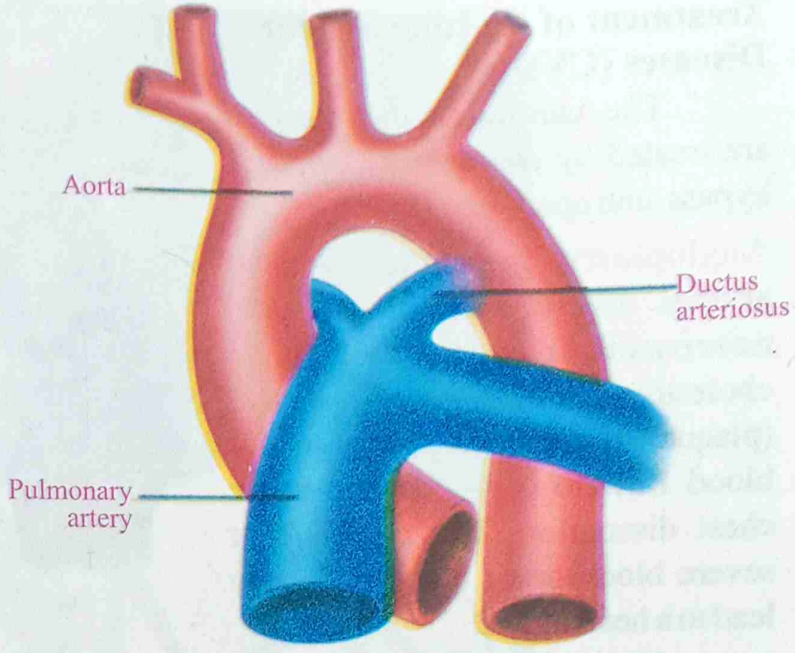

Fig. 12.15 PDA

Angiography: It is a test in which dyes that can be seen by x-rays are injected into blood vessels (either arteries or veins) and are examined by x-rays. The resulting pictures are called angiograms. The angiograms are used to diagnose the narrowing or the blockages in vessels anywhere in the body.

Do you know?

PDA is usually diagnosed using non-invasive technique like echocardiography.

The angiography can also be used to find places where arteries and veins are bulging or ballooning. These spots are called aneurysms and if this is not treated can cause death when these vessels rupture.

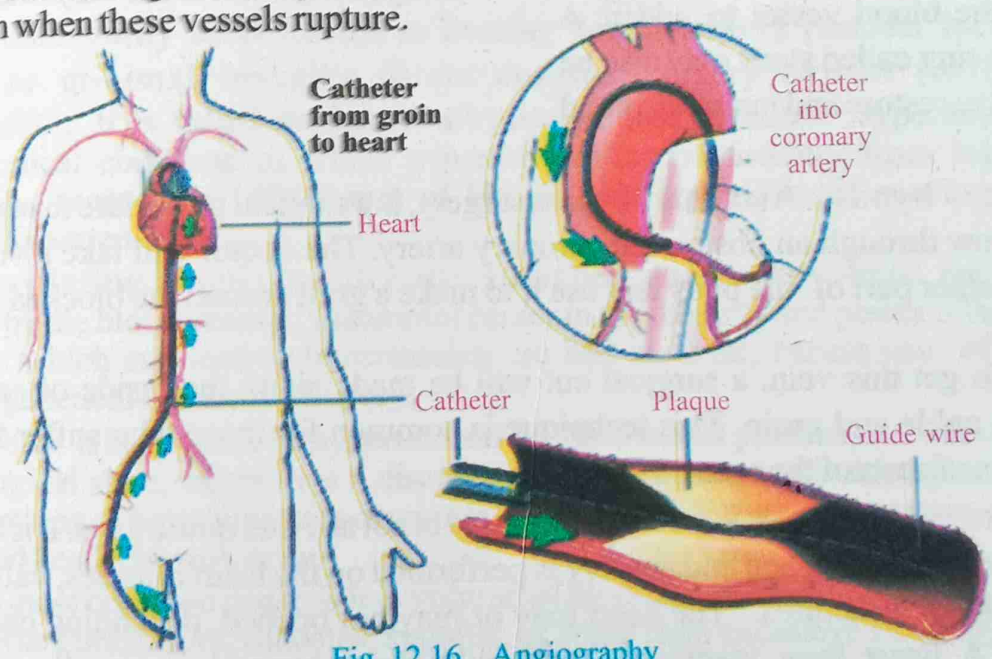

Fig. 12.16 Angiography

Treatment of Cardiovascular Diseases (CVD):

The cardiovascular diseases are treated by angioplasty, coronary bypass and open heart surgery.

Angioplasty: Sometimes our heart arteries may become blocked and narrowed from a buildup of cholesterol, cells or other substances (plaque). If it happens, it can reduce blood flow to our heart and cause chest discomfort. The complete or severe blockage of blood flow may lead to a heart attack.

Angioplasty opens blocked arteries and restores normal blood flow to our heart muscle. It is not major surgery. It is done by threading a **catheter** (thin tube) through a small puncture in a leg or arm artery to the heart. The blocked artery is opened by inflating a tiny balloon in it which forces the blood vessel to widen. A metallic ring called **stent** may also be inserted to restore and maintain blood flow.

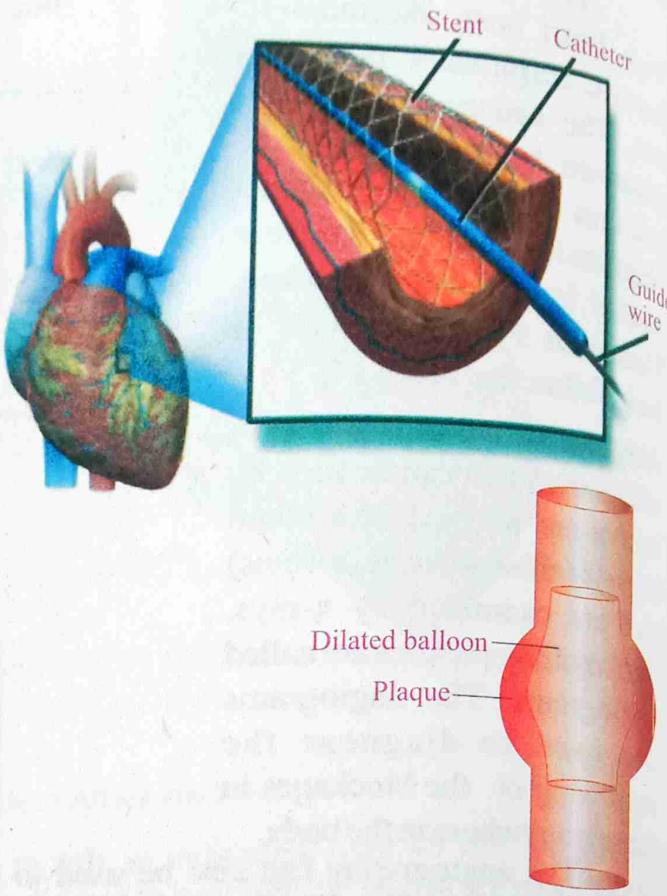

Fig 12.17 Stent in Coronary Artery

Coronary bypass: A coronary bypass surgery, is a surgical procedure to restore normal blood flow through an obstructed coronary artery. The doctor will take a vein or artery from another part of the body and use it to make a graft around the blocked area in your artery.

To get this vein, a surgical cut will be made along the inside of patients leg, between ankle and groin. This technique is common for those who suffer from severe occlusion of parts of the coronary arteries.

Open heart surgery: It is an old therapy and is not advised now a days. It is a surgery, in which the chest is opened and surgery is performed on the heart muscles, valves, arteries or other heart structures. The heart may or may not opened, depending on the type of surgery. A heart lung machine (cardiopulmonary bypass) is usually used during

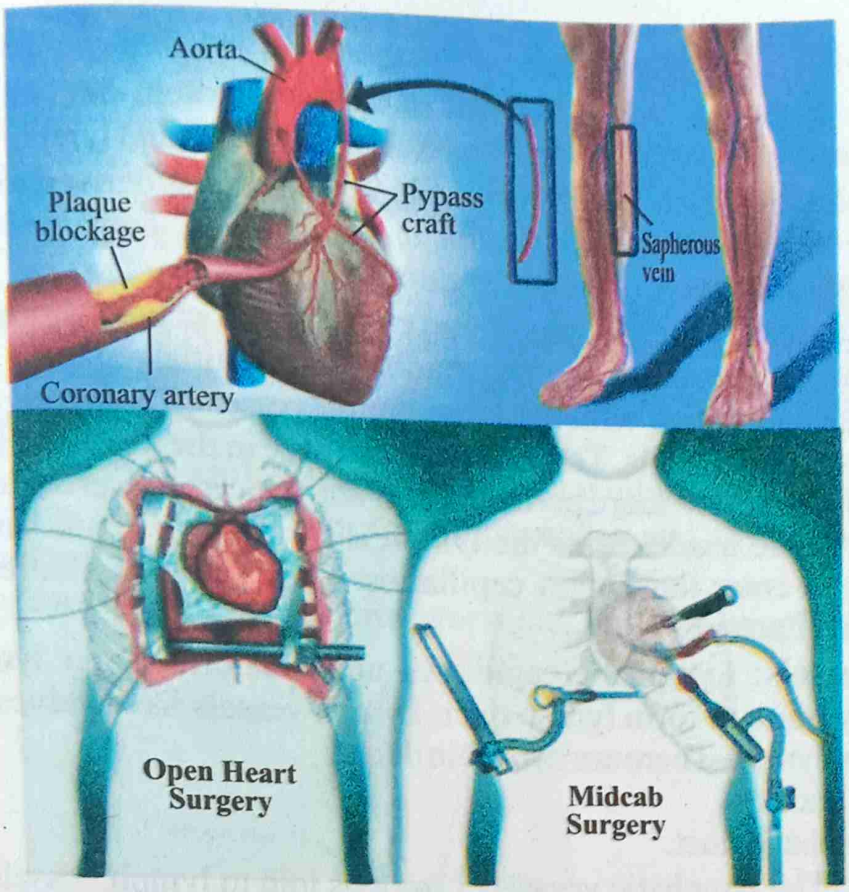

Fig. 12.18 Heart Surgery

conventional coronary artery bypass graft(CABG) surgery. After completion of surgery and the heart beat is started and provides blood and oxygen to the body the chest is again closed. There are some new surgical procedures being performed that are done in which the heart continuously beats termed as **beating heart surgery** (smaller incisions in sternum) or minimal invasive direct coronary artery bypass (MIDCAB).

Hypertension: It is called mother of all physiological diseases. Hypertension is a chronic medical condition in which a person suffers persistently from high blood pressure. i.e., more than 140/90 mm of Hg, at least two different reading apart is considered hypertension.

Factors regulating blood pressure are: Heart beat rate, stroke volume, resistance to blood flow by the blood vessels, vasomotor center in the medulla and power of heart beat. The factors which can lead to hypertension are less exercise, excess use of alcohol, ageing and genetical i.e., family history.

Hypotension: It is opposite to hypertension i.e, (**low blood pressure**). It is considered as physiological state, rather than a disease, not always but mostly due to shocks. The initial symptoms of hypotension is dizziness, fainting and seizures, chest pain, shortness of breath and headache may occur.

The most common cause is less volume of blood flow through body. It also occur in disease like Parkinson's, diabetes, syphilis, or some time excessive sweating and less fluid intake.

12.6 Lymphatic System in Human

The lymphatic system is neither closed circulatory system nor does it have pump, comprises of lymph capillaries, lymph vessels, lymph nodes and lymph.

Lymph: It is colorless fluid with in lymphatic vessels, that is derived form blood vessels (Blood plasma) and resembles to plasma in composition, contains WBC (no RBC), contains large protein, which ultimately returns to the blood.

Lymph Capillaries: These are small blind ended tubes occur in almost all tissues of all organs. They have no opening at the end, residing in interstitial regions.

They unite and merge with the large lymph vessels. Their wall consist of only a single layer of endothelial cells. The intercellular space in their wall are longer than those of the capillaries. Therefore more permeable for substances in intercellular fluid. As they are blind ended in the tissues, thus the lymph is forced by the pressure created in the interstitial fluid to enter the lymph capillaries. The lymph capillaries in the villi of intestine are called Lacteals.

Lymphatic Vessels: Lymphatic capillaries unite to form larger lymphatic vessels, which ultimately unite to form lymph duct. Lymph vessels have valves, which prevent backward flow of lymph. There are two main ducts.

i) Thoracic duct
ii) Right lymphatic duct.

Thoracic duct: The lymphatic vessels of the legs join to lymph vessels of alimentary canal and then to form the thoracic duct which empties lymph into the left subclavian.

Right Lymphatic duct: It drains lymph from the right anterior parts of the body and finally enters into the right branchiocephalic vein.

Lymph nodes: These are aggregations of lymphoid tissues having lympocytes which are small, rounded, oval or bean shaped structures, consist of lymphocytes, connective tissues and lymph vessel.

Location: In neck region, abdomen, armpit, groin, elbow and knee joint. etc.

Functions of Lymph nodes

i) Produce lymphocytes and antibodies for the defense of the body
ii) They also filter lymph (make germ free)
iii) Destroy worn out RBCs.

Lymph Masses

There are many lymphoid masses present in the wall of digestive tract in the mucosa and submusoca. The larger masses are spleen, thymus, tonsils and adenoids are all lymphoid aggregation which functions to produce lymphocytes.

Flow of Lymph in lymph vessels

The circulation of lymph is brought about by:

- Contractility of lymph vessels.

Activity of skeletal muscles, during general body movement and massage or physiotherapy.

- Movement of visceral organs.

Breathing movement

- The valve present in the wall of lymph vessels, which permit the lymph flow is only one direction i.e., towards hearts.
- The lymph from lymph duct poured into the subclavian veins.

Function of lymphatic system:

Control tissue fluid: About 3 liters fluid leaves the blood capillaries in an adult person per day. This fluid and its proteins and many other substances from the cell are returned by lymph back into the blood, and thus tissues do not face the problem of excess fluid in their intercellular space.

Transport of fatty acid and glycerol: by lacteal at villus level of ileum.

Production of lymphocytes by lymph nodes and thymus which destroy the bacteria, thus helps in defense.

Destroy and eliminate old and worn out RBC In lymph nodes especially in spleen.

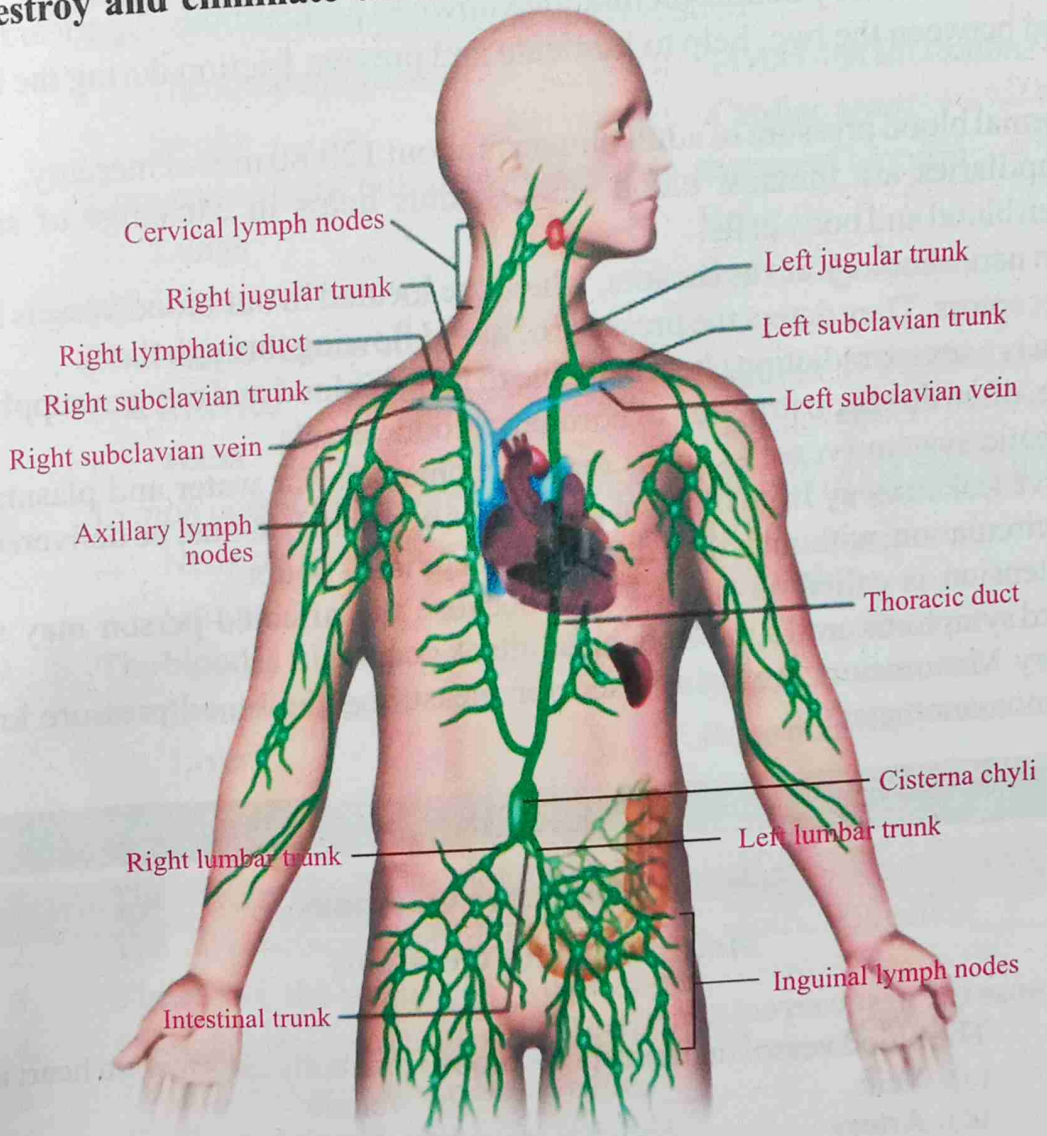

Fig. 12.19 Lymphatic system

EXERCISE

Section I: Objective Questions

Multiple Choice Questions

A. Choose the best correct answer.

1. The blood vessel that transports blood from body cells toward heart is

(a) Vein
(b) Venule
(c) Artery
(d) Arteriole

2. Which layer in arteries can withstand higher blood pressure during ventricular systole?

(a) Outer layer (b) Middle layer
(c) Inner layer (d) All these

3. The arteries divide into smaller vessels called

(a) Arterioles (b) Capillaries
(c) Venules (d) Veins

4. Artherosclerosis is mainly because of deposition' of which of the following.

(a) High level of cholesterol (b) Low level of cholesterol
(c) High level of phospholipids (d) Low level of phospholipids

5. Blockage of blood vessel in the heart by an embolus causes necrosis or damage to portion of heart muscles is called

(a) Thromboembolism (b) Myocrdial infarction
(c) Stroke (d) Cardiac arrest

6. Congestive heart failure is because of retention of blood in

(a) Lungs (b) Heart
(c) Liver (d) Both lungs and heart

7. The lymph vessels empty in

(a) Arteries (b) Arterioles
(c) Veins (d) Capillaries

8. Lymph nodes are not present in which of the following region in humans.

(a) Neck region (b) Axilla
(c) Groins (d) Stomach

9. The blood is filtered at

(a) Lymph nodes (b) Spleen
(c) Liver (d) Bone marrow

B Fill the blanks